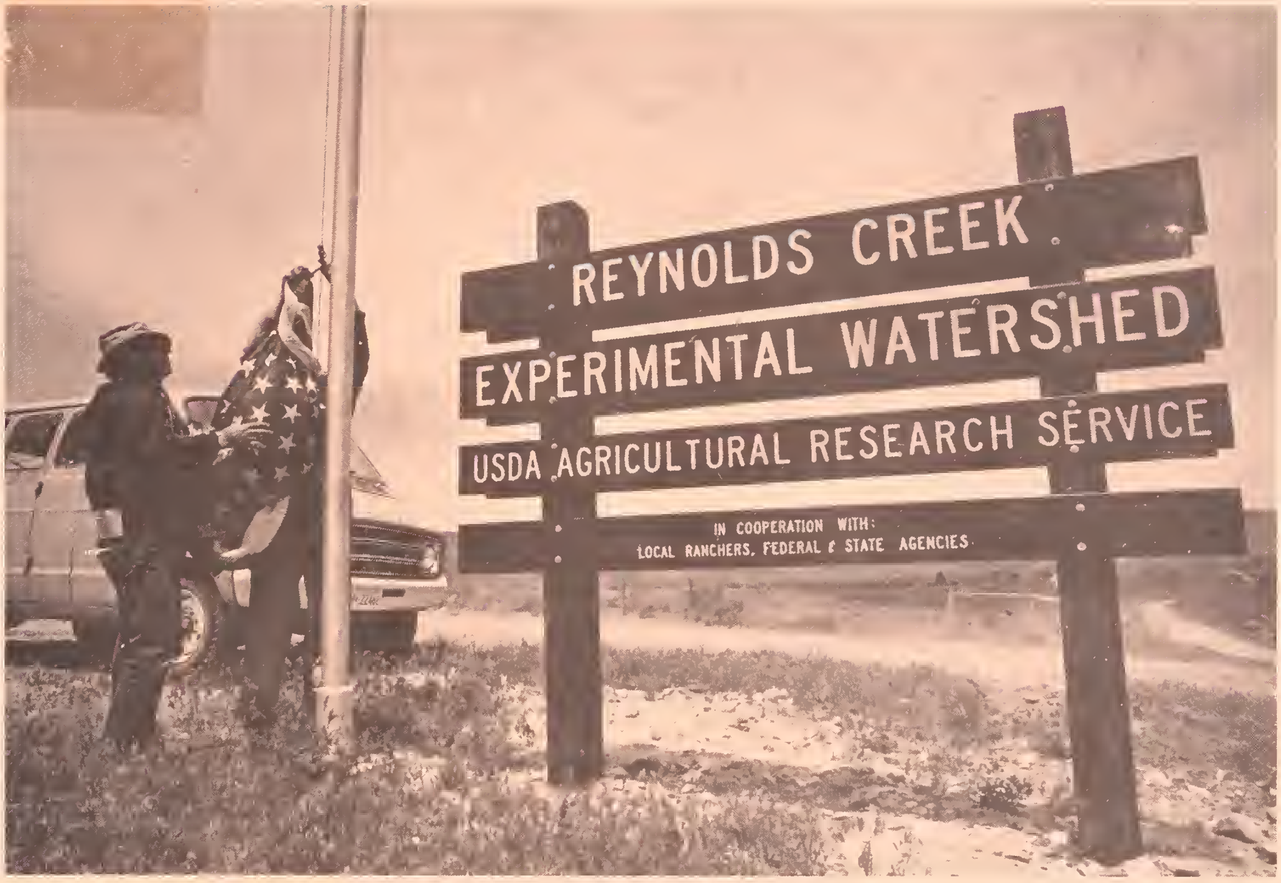
Watersheds



NORTHWEST WATERSHED RESEARCH CENTER

Reynolds Creek Experiment Station

USDA - Agricultural Research Service

In cooperation with

LOCAL RANCHERS
STATE AGENCIES
and
FEDERAL AGENCIES

NORTHWEST WATERSHED RESEARCH CENTER

Reynolds Creek Experimental Watershed

In 1958, the Senate Committee on Appropriations requested the Department of Agriculture to carry out a study of "Facility Needs--Soil and Water Conservation Research." A group appointed by the Secretary of Agriculture, upon making this study, reported to the Committee on national facility needs. One recommendation of the report was that "there should be established four to six major experimental watersheds in agricultural areas in various parts of the country." Consideration was to be given to locating one of these watersheds in the Pacific Northwest.

In 1959 Congress appropriated funds to the Agricultural Research Service to initiate research at the watershed center for the Pacific Northwest with project headquarters at Boise, Idaho.

During the latter part of 1959 and early 1960 conferences were held to inform representatives of organizations in the Northwest on the general nature and scope of the research to be initiated. Also, their specific recommendations on priorities of research problems were solicited. Some of the organizations represented at the conferences were the Agricultural Experiment Stations, Associations of Soil Conservation Districts, State Soil Conservation Commissions, Soil Conservation Service, and Forest Service. In late 1959, the Reynolds Creek Watershed location was selected.

Limited precipitation data was collected in 1960; however, quality data collection started in 1961 and runoff data collection commenced as soon as measuring sites could be constructed and instrumented. Runoff and other types of hydrologic data records for each watershed unit were started as indicated in Table 1:

TABLE 1.--Watershed Instrumentation

Name	Number	Record Began	Land Use 1/	Area Acres	Types of Data 2/
Reynolds Cr. Outlet	036068	1963	M	57,754.	1,3,4,6,7,8,9,10,11(a),12, 15,16,17,19
Murphy Creek	043004	1967	P	306.	1,4,12,14,15,16,17
Salmon Creek	046017	1964	M	8,990.	1,4,14,15,16,17,19
Mack's Creek	046084	1965	M	7,846.	1,4,14,15,16,17,19
Summit	048077	1965	P	205.	1,4,6,11(a),12,14,15,16, 17,19,20
Flat's Water-shed	057096	1971	P	2.24	1,4,11(a),12,14,15,16,19, 20
Nancy's Gulch	098097	1971	P	3.10	1,4,11(a),12,14,15,16,19, 20
Reynolds Cr. @ Tollgate	116083	1966	P	13,453.	1,3,4,8,9,10,11(a),12,15, 16,17,19
Lower Sheep Creek	117066	1966	P	33.	1,4,8,9,10,11(a),12,14,15, 16,17
Dobson Creek	135017	1973	P	3,482	1,3,4,12,14,15,16,17
Upper Sheep Cr. 1	138012	1970	P	63.4	1,3,4,11(a),14,15,16,17,19, 20
Upper Sheep Cr. 2	138034	1970	P	15.7	1,3,4,14,15,16,17,20
Reynolds Mtn. West	166074	1964	P	126.	1,3,4,7,8,9,11(a),14,15, 16,17
Reynolds Mtn. East	166076	1963	P	100.	1,3,4,7,8,9,11(a),14,15,16, 17,19,20

(a) Weekly or less frequent--by neutron probe.

1/ M = mixed
P = range

2/ 1 - Precipitation measured by recording and standard gages or recording gages only
2 - Precipitation, by standard gages only
3 - Snow, from snow courses
4 - Runoff, continuous records
5 - Runoff, peak stages only, as from crest gages
6 - Ground water levels from wells
7 - Pan evaporation
8 - Air temperature, maximum and minimum of recording
9 - Humidity, daily or oftener
10 - Solar radiation
11 - Soil moisture (indicate by footnote how often measurements are taken)
12 - Frost depths
13 - Soil temperature
14 - Land use, annual or oftener
15 - Condition of vegetative cover and field operations
16 - Detailed soil survey available
17 - Topographic map available
18 - Profile and cross sections of channels available
19 - Sediment, by suspended sampling
20 - Sediment, by silt box and/or Coshocton wheel

The Northwest Watershed Research Center is an element of the Utah-Idaho-Montana Area Office, Western Region, ARS, USDA. Its research program serves the Owyhee Plateau Area of the Columbia River Basin and similar Soil Conservation Program Areas in the Northwest. Action agency research needs of greatest urgency in the region are precipitation-runoff relationships, snow distribution and melt, sedimentation, channel stability, erosion prediction and control, optimum management practices for rangeland, and conservation of water quality. Its present field program is headquartered in the Reynolds Creek Watershed, located 55 miles southwest of Boise, Figure 1. The Center headquarters is at Boise, Northwest Watershed Research Center, 306 N. 5th Street, P. O. Box 2700, Boise, Idaho 83701.

The mission of the Northwest Watershed Research Center, in response to the needs of the region, is to conduct research with the following objectives:

1. Develop techniques for inventorying snow accumulation, distribution, and water equivalent of continuous and isolated snowpacks. Determine the factors affecting timing and rates of snowmelt and formulate alternative procedures for predicting or forecasting runoff from melting snow, rainfall, or both where the ground may or may not be frozen.

2. Formulate and test rangeland watershed models which interface models for precipitation, snowmelt, infiltration, ET, subsurface flow, and surface flow, for predicting or forecasting streamflow, water yield, and/or water balances.

3. Derive and test models for prediction of rangeland erosion, channel degradation and/or aggradation, and downstream sediment yield.

4. Develop water quality models for rangeland watersheds that combine runoff models, erosion and sediment yield models, and rangeland management models, which predict water quality parameters for in-stream or off-stream uses.

5. Establish the effects of rangeland management systems on soils and range conditions and productivity.

In concert with local, state, and federal soil and water oriented agencies, the Northwest Watershed Research Center conducts cooperative research and develops principles for direct application to action program needs.

Cooperative research results in basic data and/or methods for specific application to the research need. Cooperative research is with the

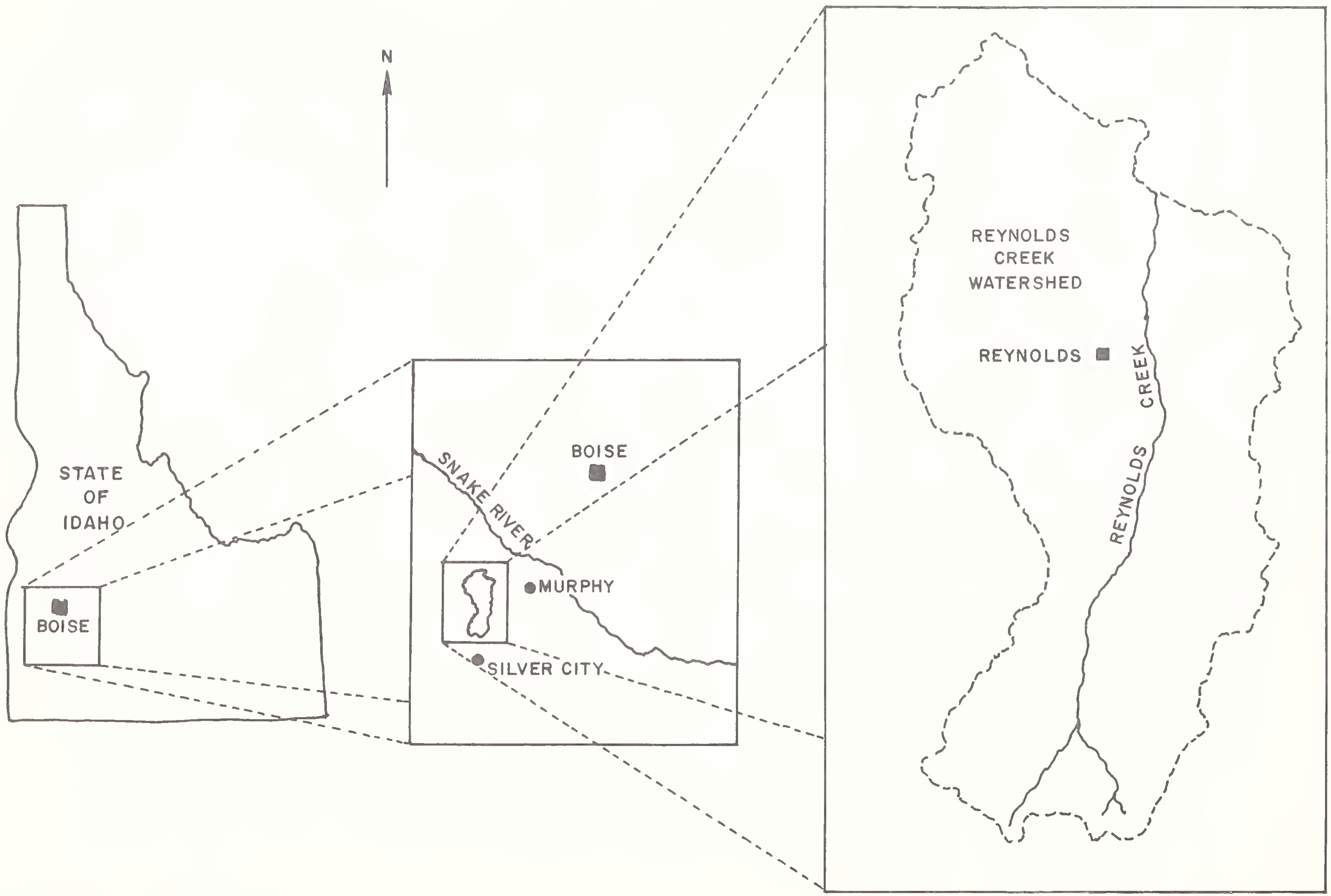


Figure 1. Location Map

Bureau of Land Management, the Soil Conservation Service, the Agricultural Experiment Stations, and Water Resources Centers of the regional states, the Idaho State Department of Water Resources, and Boise State University.

Reynolds Creek is a north-flowing tributary of the Snake River with its confluence near Walter's Ferry. The watershed comprises the upper 90-square miles of the total Reynolds Creek Watershed. The field headquarters in Owyhee County is near the original site of Reynolds, Idaho, and 15 miles west of Murphy, Idaho.

According to Mildretta Adams (1960) in her "Historic Silver City", Reynolds Creek was named by a party under Michael Jordan after the "laziest man in the party." The first toll road was built up Reynolds Creek to Silver City in 1864. This marked the beginning of settlement and utilization of the range resources of the valley. Water rights on Reynolds Creek are among the oldest in Idaho, established in the early 1860's. The water was used for irrigating hay and truck crops to supply the mining community of Silver City, just over the divide to the southwest. The fair stands of timber that existed in the upper portion of the watershed furnished much of the mine timbers. Scattered juniper, mountain mahogany, and patches of fir and aspen have probably not changed much. Starting in the 1880's great herds of cattle and sheep were trailed across the Reynolds Valley to the railhead at Murphy for shipping. The ewes were again trailed back to their range. Since about 1910 cattle have replaced sheep on the range. Presently, Reynolds Creek Watershed furnishes forage for 2,500 cows and calves. About 2,000 acres of irrigated bottom land provides hay and forage for wintering.

The watershed soils, geology, vegetation, and land use and treatment represent plateau and foothill grazing areas of the Northwest. Elevations range from about 3,600 feet to 7,300 feet. Annual precipitation varies from 10 inches at the lower elevation to near 50 inches at the higher elevations. Approximately two-thirds of the area is public land and one-third private land. Nearly 75 percent of the annual runoff is from snowmelt; however, flash runoff from smaller areas does occur from intense summer rain storms. Severe winter flooding and erosion occur in the winter from rain on snow with frozen soil conditions. Views of the lower and upper watershed are shown in Figures 2a and 2b.

The following sections discuss the particular programs of the watershed research project.

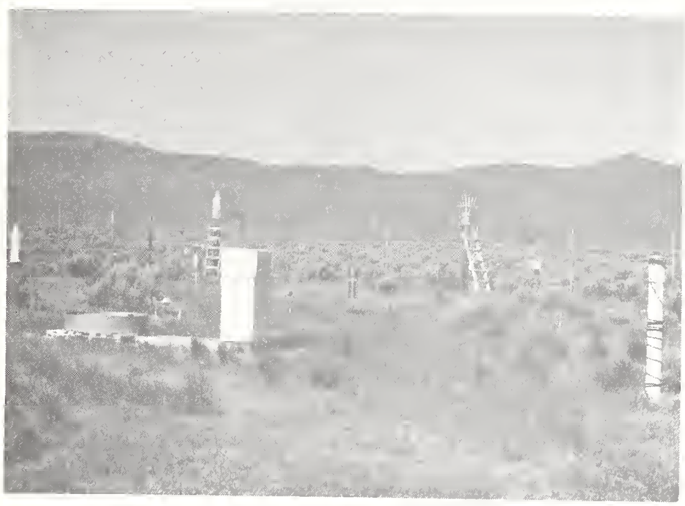
Figure 2a. View of the Lower Watershed, Summer

Figure 2b. View of the Upper Watershed, Spring

FIELD HEADQUARTERS

The field operation is located at Reynolds, Idaho.

Reynolds Creek, Idaho Weather Station



Equipment repair, storage, and maintenance activities are based at this location.

DATA COLLECTION AND PROCESSING

Figures 3a and 3b show the field activities involved in data collection. The flow chart in Figure 4a gives the general procedure followed in our extensive data reduction process. The precipitation and runoff charts are hand edited and digitized, as shown in Figures 4b and 4c, and then checked for errors using either the IBM 360/75 at the Idaho Nuclear Corporation facilities in Idaho Falls, Idaho or an IBM 370/145 at the Idaho State Auditor's Office in Boise. After the data have been error checked they are loaded on magnetic tapes for future use on the IBM 360/75. Other data, such as soil water, are punched from field sheets and stored on magnetic tape after they have been error checked. All data on magnetic tape are also stored on microfilm for office use.

Figure 3a. Calibrating a rain gage

Figure 3b. Servicing a runoff measuring station

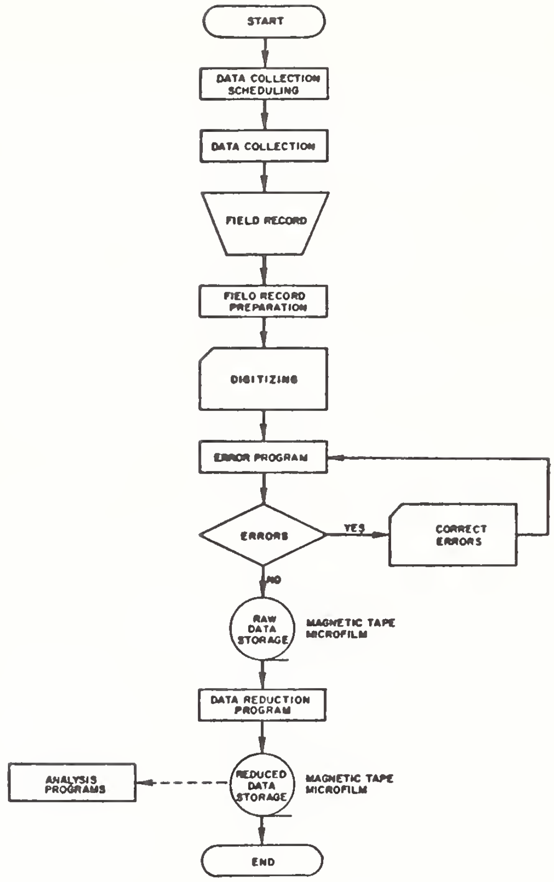


Figure 4a. Data Processing Flow Chart

Figure 4b. Processing Charts

Figure 4c. Digitizing Charts

PRECIPITATION

No dense recording rain gage network existed in the Northwest prior to establishment of the Northwest Watershed Research Center. Such a network is necessary to delineate spatial and temporal precipitation variability on watersheds. The objective of the Reynolds Creek Watershed precipitation network is to provide data to (1) develop and compute parameters that characterize precipitation rates and amounts for application to runoff and erosion predictions, (2) establish general precipitation-elevation-aspect-slope relationships for hydrologic and forage production forecasting, (3) develop depth-duration-frequency and depth-area-duration relationships for application to similar rangeland watershed areas, and (4) predict precipitation inputs to hydrologic models for the Reynolds Creek and similar rangeland areas.

A network of nearly 100 unshielded recording rain gages, about one gage per 260 ha (1 mi^2), was operated from 1961 through 1967 (Hershfield, 1971). Analyses of data collected from this network were reported by Cooper (1967). However, because of wind and snow and the lack of sheltered gage sites, precipitation catch in gages at elevations above 1,500 m (5,000 ft) was significantly less than actual precipitation measured by other methods. Consequently, a network of dual precipitation gages was installed in 1967-1968.

The present Reynolds Creek precipitation network consists of 46 dual-gage sites at an approximate density of one site per 5.18 square kilometers. Site locations and average annual precipitation are shown in Figure 5. Each site is instrumented with two recording rain gages, mounted on posts, with the collectors at 3.04 meters (Figure 6a). One of the gages is shielded by a modified Alter shield, with the baffles constrained at 30 degrees from vertical to maintain a constant airflow across the collector. The second gage is unshielded. Gages are calibrated periodically to insure accurate recording.

The purpose of the dual-gage network is to apply a procedure for calculating "true" precipitation, especially in areas of snowfall, since the combination of wind and snow is the major source of error in gage catches. The method used at Reynolds Creek for computing "true" precipitation was an equation developed by Hamon (1972):

$$\ln (U/A) = B \ln (U/S) \qquad (1)$$

where U is the unshielded gage catch, A is actual or computed precipitation, B is the calibration coefficient, and S is the shielded gage catch. Actual precipitation data were used to evaluate B in equation 1.

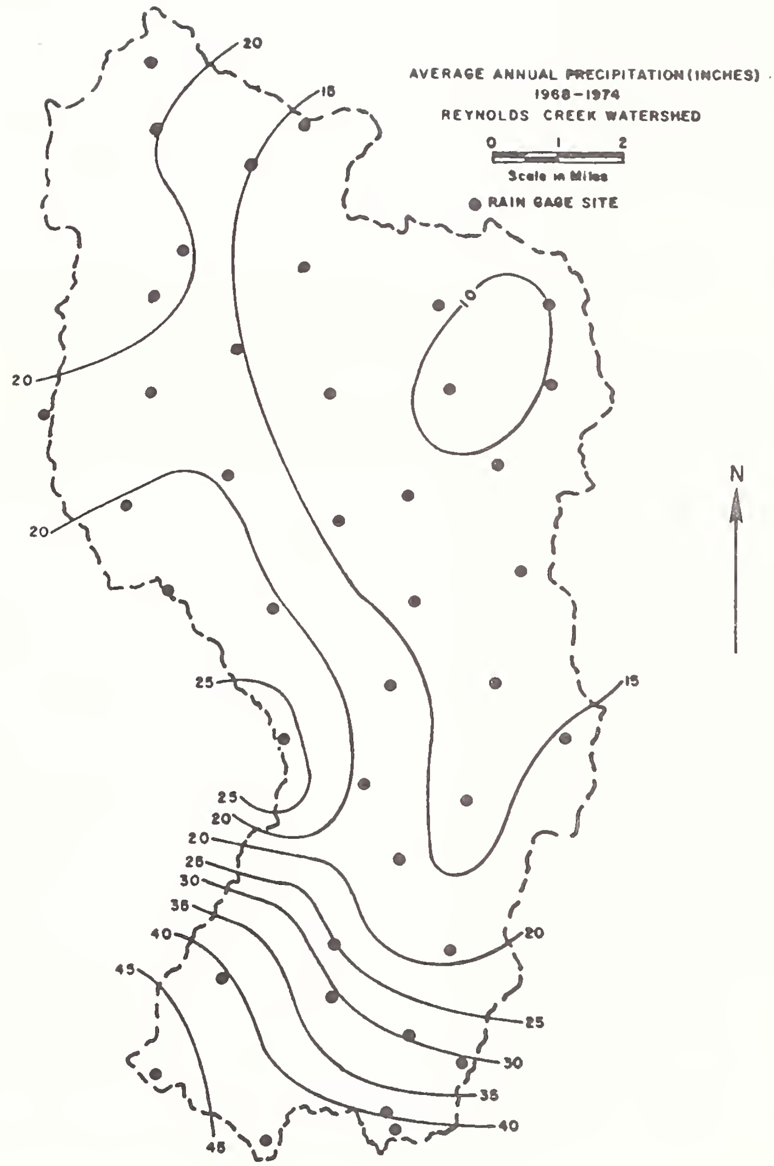


Figure 5. Average Annual Precipitation

Figure 6a. Dual Precipitation Site

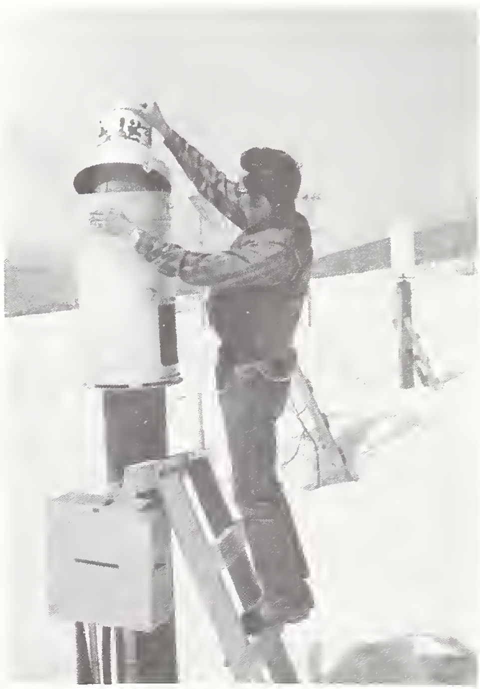


Figure 6b. Scheduled Gage Check

The sensitivity of the calibration coefficient, B, which ranged between 1.70 and 1.90 gave a "true" precipitation ranging from 1 to 11 percent, with an average difference of 5 percent.

Since water balance and hydrologic model studies require an accurate precipitation input, precipitation can now be used with greater confidence as input to these models. Figure 5 is an isohyetal map of the average annual precipitation on the Reynolds Creek Watershed.

A precipitation intensity program is used to compute storm intensities for all dual-gage sites for the years 1968-1973. For the purpose of this program, a storm is defined as a precipitation accumulation of 0.25 inch or greater and where periods of no precipitation are less than 4 hours. A sample computation of maximum intensity at one gage site is shown below, Table 2. Similar data is available at all sites. Data processing of the early network (1961-1967) is now in final stages.

TABLE 2.--Maximum intensities at one gage site for the years 1968 through 1973

Time Period	Maximum Intensity (Inches/Hour)						
	1968	1969	1970	1971	1972	1973	All Years
5 min.	2.16	2.64	2.63	2.52	2.26	1.24	2.64 (1969)
10 min.	1.98	2.58	1.96	2.22	1.85	1.24	2.58 (1969)
15 min.	0.86	1.95	1.57	1.62	1.30	0.84	1.95 (1969)
20 min.	0.72	1.63	1.19	1.32	1.03	0.64	1.63 (1969)
30 min.	0.67	1.39	0.82	1.03	0.75	0.44	1.39 (1969)
1 hr.	0.63	0.87	0.24	0.59	0.42	0.33	0.87 (1969)
2 hr.	0.37	0.48	0.20	0.30	0.25	0.27	0.48 (1969)
4 hr.	0.19	0.29	0.12	0.15	0.18	0.24	0.29 (1969)
6 hr.	0.14	0.16	0.06	0.13	0.13	0.21	0.21 (1973)
12 hr.	0.10	0.07	0.05	0.07	0.07	0.13	0.13 (1973)
24 hr.	0.00	0.00	0.00	0.04	0.00	0.00	0.04 (1971)

SNOW

The economy of many western valleys, such as Reynolds Valley, depends on the amount of water that is annually stored in the mountain snowpack. Since no storage facility is provided for the extended use of this water, it must be utilized as it runs off. Annual forecasts of snowmelt runoff are thus required for anticipating forage production. Potential management of snow accumulation sites for modulating snow depths, drift shape, and melt rates needs to be investigated.

Destructive late winter and spring floods in the Northwest frequently originate from rapid melting snow at low elevations characteristic of the sagebrush zone. Although there is little likelihood of modifying snowmelt rates enough to alleviate this threat, knowledge about the behavior of snow in the sagebrush zone will be helpful in devising better warning and forecasting techniques that may reduce the danger to life and property from snowmelt floods.

There are three unique situations associated with snow research underway at the Watershed Center:

1. Shallow snow cover at lower elevations that is continuously changing in depth, water content, and areal distribution through the winter months.

2. Deep, continuous snowpacks that occur at the higher elevations.

3. Large snowdrifts located on north and east slopes that persist late into the snowmelt season.

The snow research program is directed toward the goal of developing workable models for each type of snow cover which will predict the daily rate of snowmelt by using a minimum of parameters. This model will be based upon the physics of the snowmelt process and take into consideration such factors as wind, vegetation, frozen soil conditions, and the effects of terrain features on snow distribution and ablation (Zuzel and Cox, 1975).

The areal distribution of snow and how much water is in storage at any one time and how this storage volume changes from day to day on a watershed basis is required for water balance calculations. A photogrammetric method has been tested for determining the depth and areal distribution of snow over a selected study basin. This method is similar to the procedure used in making a topographic map and requires the placement of control markers on the snow surface at selected control points prior to each flight. Measuring snow depths and the areal distribution of snow

by aerial photogrammetry on the 100-acre Reynolds Mountain Watershed was shown to be a practical method for obtaining detailed information on the distribution of snow in areas of complex relief (Cooper, 1965).

Figure 7a. Snow Course Survey, Tollgate Watershed

Although the snow depth over an area may be accurately determined by this method, progress needs to be made on predicting the aerial variation in snow density (Figure 7a).

Reynolds Creek studies indicate that at least 66 percent of the annual snowfall is stored in less than 30 percent of the area (Rawls, Hanson, and Robertson, 1975).

These deposition areas are of importance to the survival of the flora and fauna of western rangelands. The prolonged water yield from many of these drift areas is also of prime importance for water users downstream from these rangeland watersheds. Each snowdrift functions as a small reservoir, which supplies water over a prolonged period of time and, therefore, allows extended use of the surrounding area (Figure 7b).

Figure 7b. Aerial Photograph of Snowdrift Locations. June 10 Photograph.

Research is underway for determining the optimum size, shape, and location of these snowdrifts for minimizing evaporation and sublimation losses and maximizing and prolonging water yield from these areas. Energy exchange measurements on these isolated drifts have shown that 54 percent of the energy available for ablation comes from sensible heat transfer and 46 percent from radiant heat. This is contrasted to continuous snow cover conditions where practically all of the energy comes from radiant heat transfer. Drift profile studies showed that the top of the drift surface ablated 23 percent faster than the more abrupt face.

Management of snowdrift shape by natural barriers or fences could, by reducing the flat top and increasing the slope, significantly reduce evaporation losses. Also, barriers would tie down snow particle sources rather than having them blow around. Sublimation losses from snow particles while wind blown, are very high. An optimum shape of the drift would also prolong melt into the summer season, and extend soil water supplies and water yield to streams. A trial planting of Monterey Knob Cone Pine trees was made at one drift site to test the possibility of using natural vegetation for snow management purposes. Two hundred trees were planted in two rows, 2 feet (.61 m) apart at the toe of an existing snowdrift in the center of a mile long drift area. Approximately 30 percent of the trees have survived to date.

Melt from the drifts not only provides most of the dependable water yield from watersheds such as Reynolds Creek, but also furnishes soil water to deep soil laid slopes. Nonproductive vegetation now uses this water. An opportunity exists for increasing the productivity of these areas by vegetation management and modulating snowmelt.

Streamflow forecasting research has involved long-term and short-term snowmelt-runoff models. Both models were initially developed and verified, using streamflow data from the Tollgate Weir, Figure 8a and 8b. The long-term model predicts streamflow volume, using water content data from snow courses located in the drainage. A pattern search optimization method is used to generate the forecast equations. The short-term model predicts mean daily flows, one day in advance, using daily melt values from a universal gage located in the Reynolds Mountain Study Basin.

Figure 8a. Tollgate Outlet, Snowmelt Runoff

Figure 8b. Tollgate Drainage

Additional snow research is being cooperatively conducted with the Soil Conservation Service and the Idaho Department of Water Resources on deep, continuous snowpacks at higher elevations in the Boise River Drainage. It is concerned with developing and refining both short and long-term streamflow forecast models for this drainage (Norris and Cox, 1974). One of the key sites of this study is located at Trinity Mountain (Figure 9a). It is located in the approximate center of a 6,475 km^2 (2,500 sq. mi.) timbered watershed at an elevation of 2,347 m (7,200 ft). On the average, 1,092 mm (43 in.) of water are in storage at this site on May 1 of each year. Both of the streamflow models developed at Reynolds Creek have been successfully applied to the Boise River Watershed (Cox and Zuzel, 1973; Zuzel, Robertson, and Rawls, 1975).

Special studies have been conducted on these timbered watersheds to determine the relative importance of meteorological variables in snowmelt forecasting. Preliminary results show that a 13 percent improvement in snowmelt forecasting can be achieved by using vapor pressure, net radiation, and wind, rather than just temperature alone (Zuzel and Cox, 1975).

Figure 9a. Trinity Mountain Site

Figure 9b. Fabricating Electronic Instrumentation

VEGETATION

Quantitative data on herbage yield from rangelands under different levels of management are needed to guide land managers in coordinated multiple use of the range. These needs require more discerning information on how vegetation and soils respond to imposed treatments, including controlled grazing. Information is also needed with regard to methods of increasing cover and to the rate of recovery of native range following intensive practices. Vegetation data provide input to:

1. Determine the effects of grazing management and treatments on yields of herbage, cover production, soil moisture regime, and soil surface conditions at selected sites.

2. Study changes in plant density and plant composition as a result of grazing management and treatments.

In cooperation with the Bureau of Land Management, USDI, nine experimental sites have been established at different elevations and precipitation zones on the watershed in order to meet the above objectives. Location of the study sites is shown in Figure 10, and information regarding these sites is given in Table 3.

Chemical spray and mechanical removal of sagebrush has been investigated as a technique for improving the understory vegetation at dense vegetation sites. The average nonsage herbage yields for the 5-year period 1971-1975, for the mechanical and sprayed treatments were 1,314 and 1,494 lbs of dry forage per acre. This compares with only 757 lbs per acre from no treatment. The average air dry forage yield from the grazed treatment was 911 lbs per acre. These results are shown in Figure 11.

Soil water content has been measured under the different brush treatments during the growing season in order to determine whether the water use regime from the mechanical or chemical treatment is different from no treatment. There are no apparent differences in water use due to treatment.

Plant adaptability nursery sites were prepared and nurseries were seeded late in 1974 at three sites with different precipitation patterns. These sites were Flats, Nancy Gulch, and Reynolds Mountain (refer to Table 3). With the cooperation of the Intermountain Forest and Range Experiment Station, U.S. Forest Service, a wide selection of material was obtained for each of the nurseries. Plant emergence and survival information will be noted with regard to each selection. This information will aid in the selection of plant species used in range reseeding.

TABLE 3.--Tabulation of site information

Site	ELE. (feet)	SLOPE (percent)	ASPECT OF SLOPE	PRECIP. (inches)	VEGETATIVE COVER (percent)	SCS HYDRO. CLASS.
		SPARSE VEGETATION SITES				
Flats	4000	5	N	10	25	B
Nancy's Gulch	4600	8	NE	13	25	C
Lower Sheep Creek	5400	16	NW	14	25	B
Upper Sheep Creek	6100	25	SW	20 1/	25	D
Reynolds Mountain West	6850	5	SW	43 1/	25	B
		DENSE VEGETATION SITES				
Nettleton's	5000	25	W	30	50	D
Reynolds Mountain East	6800	6	NW	43 2/	50	B
Upper Sheep Creek	6100	33	NE	20 2/	50	C
Whiskey Hill	5550	15	E	14	50	B

1/ Snow removed by wind

2/ Snow deposition zone

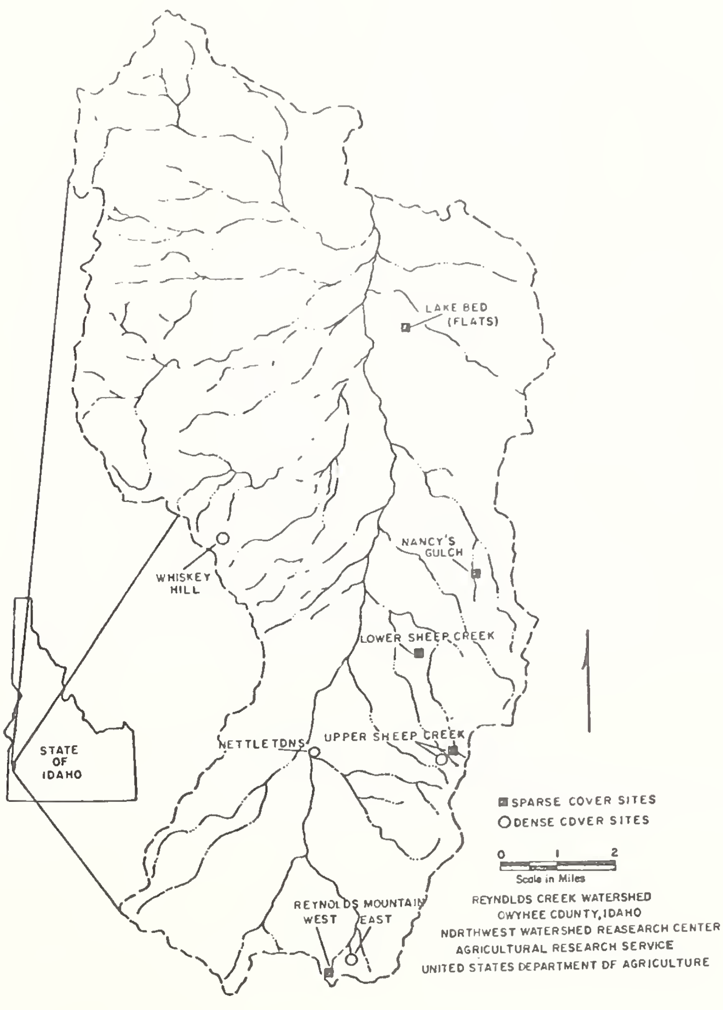


Figure 10. Location of experimental sites.

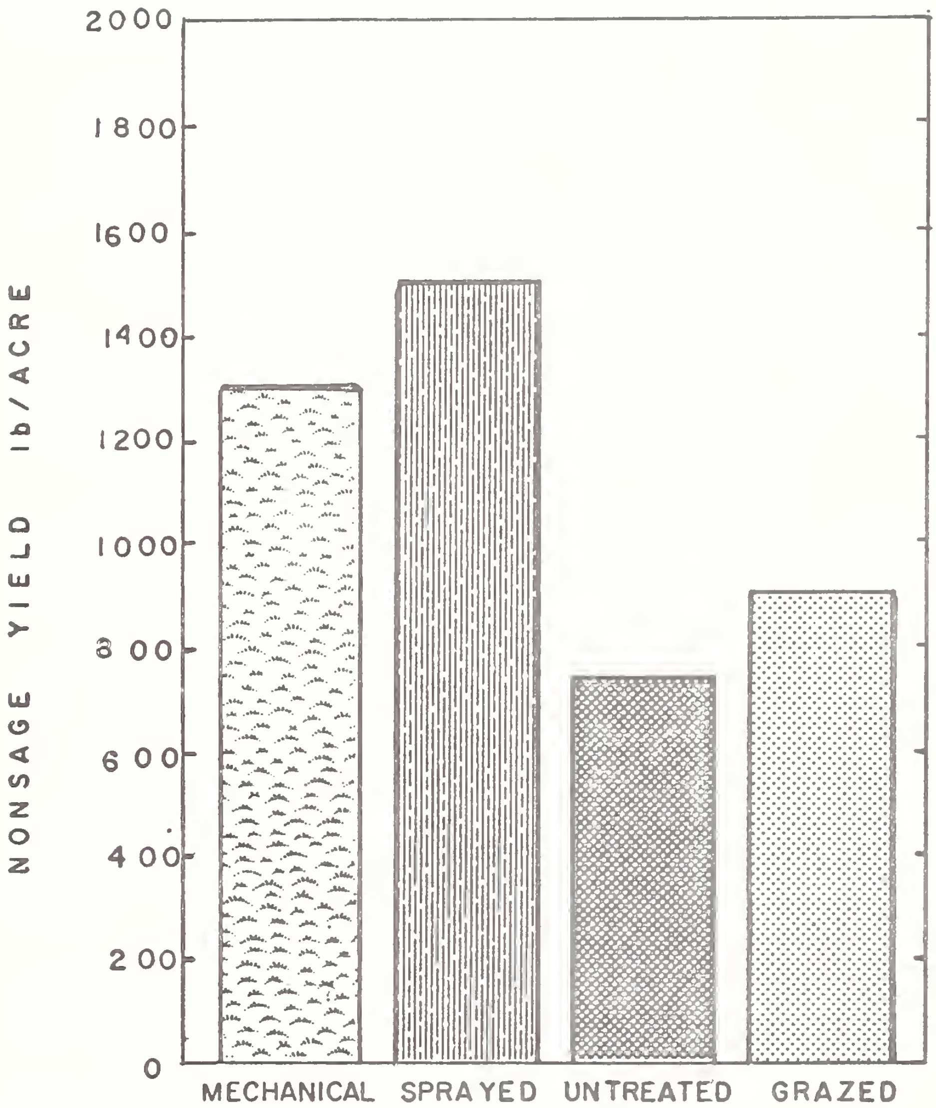


Figure 11. Average Yield of Nonsage Plant Material at Upper Sheep Creek from 1971-1975

More than 70 plant families have been identified on the watershed and more than 500 different species have been collected and entered in the herbarium maintained in Boise. Some of the more prevalent species are given in Table 4. Figure 12 presents a generalized vegetation map for the watershed. Figure 13a shows a typical site. In Figure 13b range technicians are clipping for plant composition and yield determinations.

TABLE 4.--Partial list of plant species found on Reynolds Creek Experimental Watershed.

(*Abies lasiocarpa*) alpine fir
(*Acer* spp.) maple
(*Agropyron* spp.) wheatgrasses
(*Agropyron spicatum*) bluebunch wheatgrass
(*Alnus* spp.) alder
(*Artemisia tridentata*) big sagebrush
(*Artemisia arbuscula*) little sagebrush
(*Artemisia spinescens*) budsage
(*Artemisia vaseyana*) Vaseyana sagebrush
(*Atriplex confertifolia*) shadscale
(*Bromus tectorum*) cheatgrass
(*Cercocarpus ledifolius*) mountain mahogany
(*Elymus cinereus*) giant wildrye
(*Festuca idahoensis*) Idaho fescue
(*Grayia spinosa*) spiny hopsage
(*Koeleria cristata*) Junegrass
(*Lupinus* spp.) lupine
(*Poa* spp.) bluegrasses
(*Poa secunda*) Sandberg bluegrass
(*Populus tremu loides*) quaking aspen
(*Populus trichocarpa*) cottonwood
(*Pseudotsuga menziesii glauca*) Douglas-fir
(*Prunus emarginata*) bitter cherry
(*Prunus virginiana*) chokecherry
(*Purshia tridentata*) bitterbrush
(*Ribes* spp.) currant
(*Salix* spp.) willow
(*Salvia dorrii carnosa*) desert sage
(*Sarcobatus vermiculatus*) big greasewood
(*Sibbaldia procumbens*) creeping sibbaldia
(*Sitanion Hystrix*) squirreltail
(*Symphoricarpos* spp.) snowberry

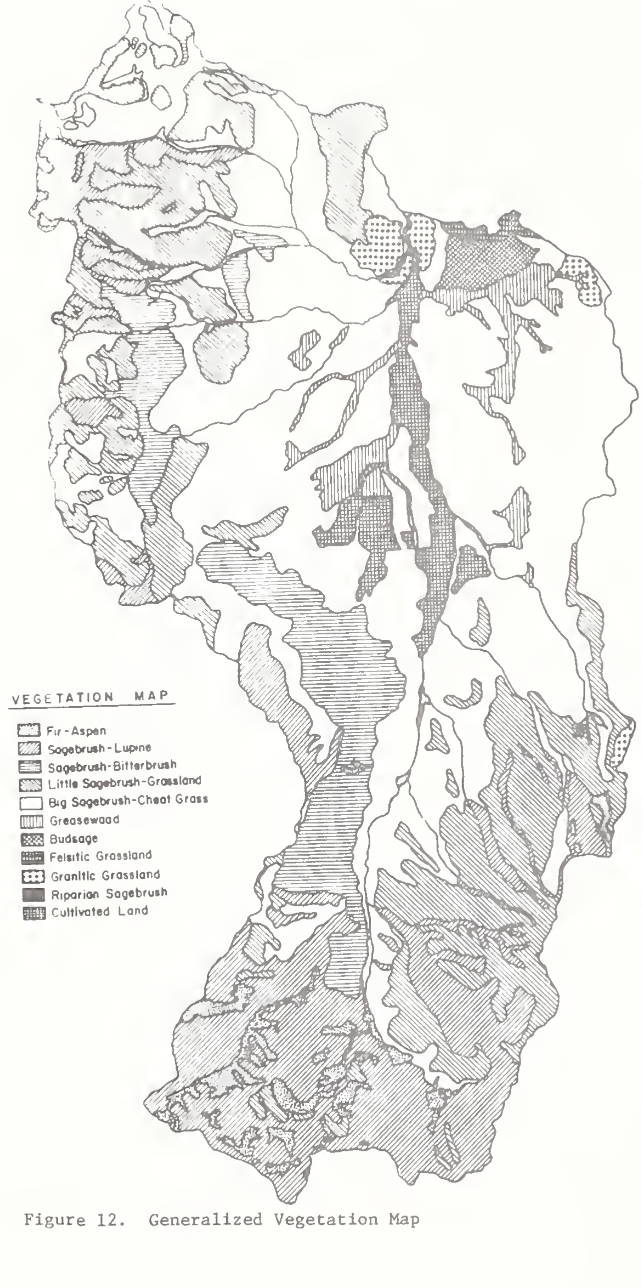


Figure 12. Generalized Vegetation Map

13a. Cattle graze the slopes of Reynolds Creek Experimental Watershed from April through September.

13b. Technicians clipping at the Flats Study Site for determining herbage yield.

GENERAL DESCRIPTION OF SOILS
REYNOLDS CREEK EXPERIMENTAL WATERSHED

In cooperation with the Soil Conservation Service, work on a detailed soil survey of the Reynolds Creek Experimental Watershed began in 1963 with the correlation and mapping of the soil units completed in 1965. The soil survey report of Reynolds Creek Watershed will be published in 1976.

Soil profiles typical of four of the soil sites are shown in Figure 14a. The Watershed consists of eight main soil association areas (Figure 14b). The approximate number of acres for each association is given in Table 5.

TABLE 5.--Approximate number of acres for each soil association on the Reynolds Creek Watershed

Soil Associations	Acres
Takeuchi-Kanlee-Ola	5,640
Harmehl-Gabica-Demast	12,062
Searla-Bullrey	2,024
Glasgow-Lassen	1,922
Nannyton-Larimer-Ackmen	6,368
Bakeoven-Reywat-Babbington	15,407
Farrot-Castlevale-Brownlee	2,927
Hoot-Nannyton	781

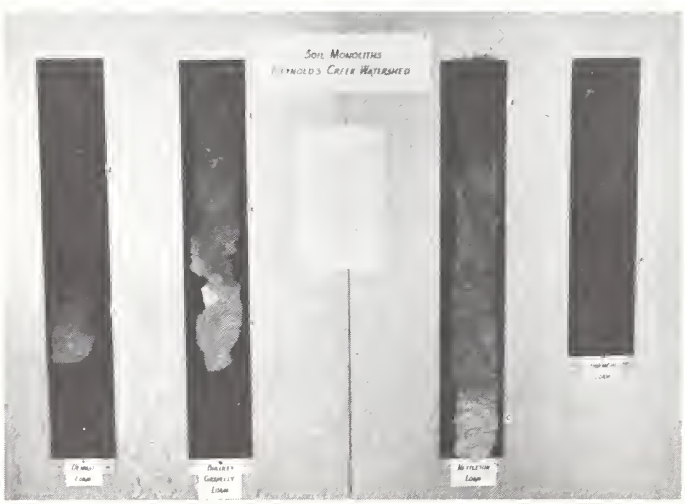


Figure 14a. Soil Monolith of Four Soils

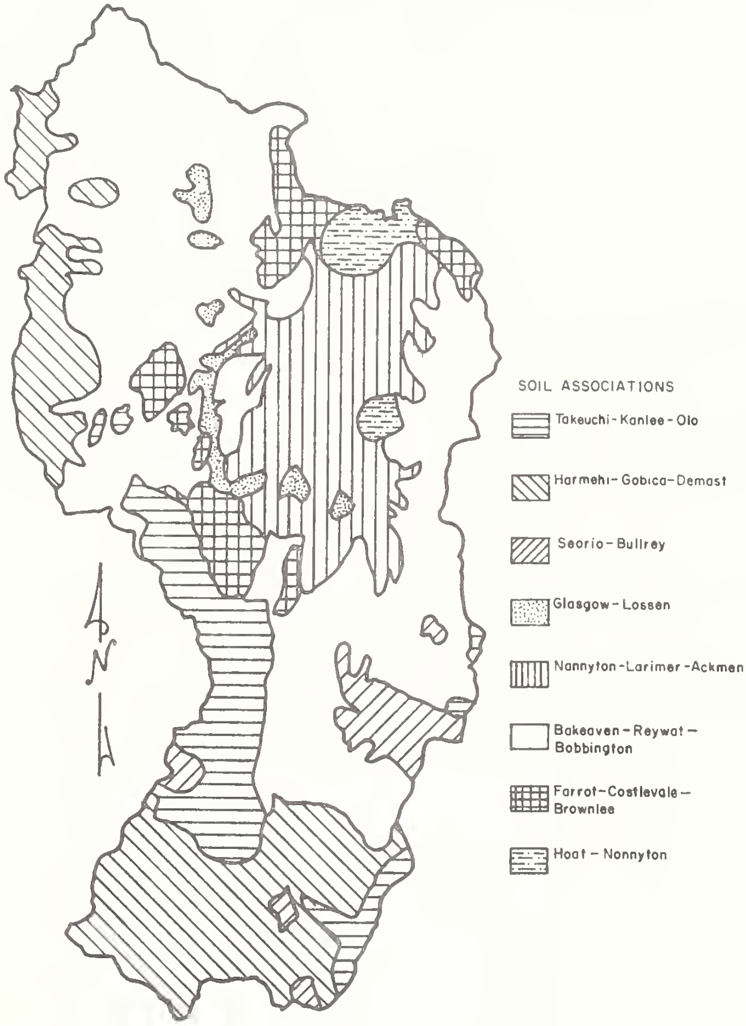


Figure 14b. Soil Associations Map

GENERALIZED GEOLOGY OF THE REYNOLDS CREEK WATERSHED

Granitic rock of Cretaceous age underlies Cenozoic strata throughout the entire watershed. The granitic rock, possibly a stock of the Idaho Batholith, crops out repeatedly along the perimeter of the drainage divides. The overlying Cenozoic strata can be subdivided into three sequences as follows:

a) Salmon Creek Volcanics - basalt and andesitic lavas of Miocene age.

b) Reynolds Basin Group - lake sediments with intertongueing of basaltic lavas of Miocene to early Pliocene age.

c) Rhyolitic welded tuffs of Pliocene age.

The structural complexities of the watershed are considerable with faulting prevalent throughout. Displacement of over 1,000 feet has been determined on one fault. An erosionally modified anticlinal fold forms the major topographic feature and a syncline forms the valley floor. Drainage patterns have been established along both structural trends and stratigraphic contacts. These same structural and stratigraphic features are important to the occurrence of ground-water discharge springs and baseflow.

Basaltic and silicic volcanics cover approximately 67% of the watershed, granite 18%, lake sediments 13%, and alluvium 2%.

The generalized geologic map of the Reynolds Creek Watershed is shown in Figure 15. A more detailed geologic map is found in the Appendix.

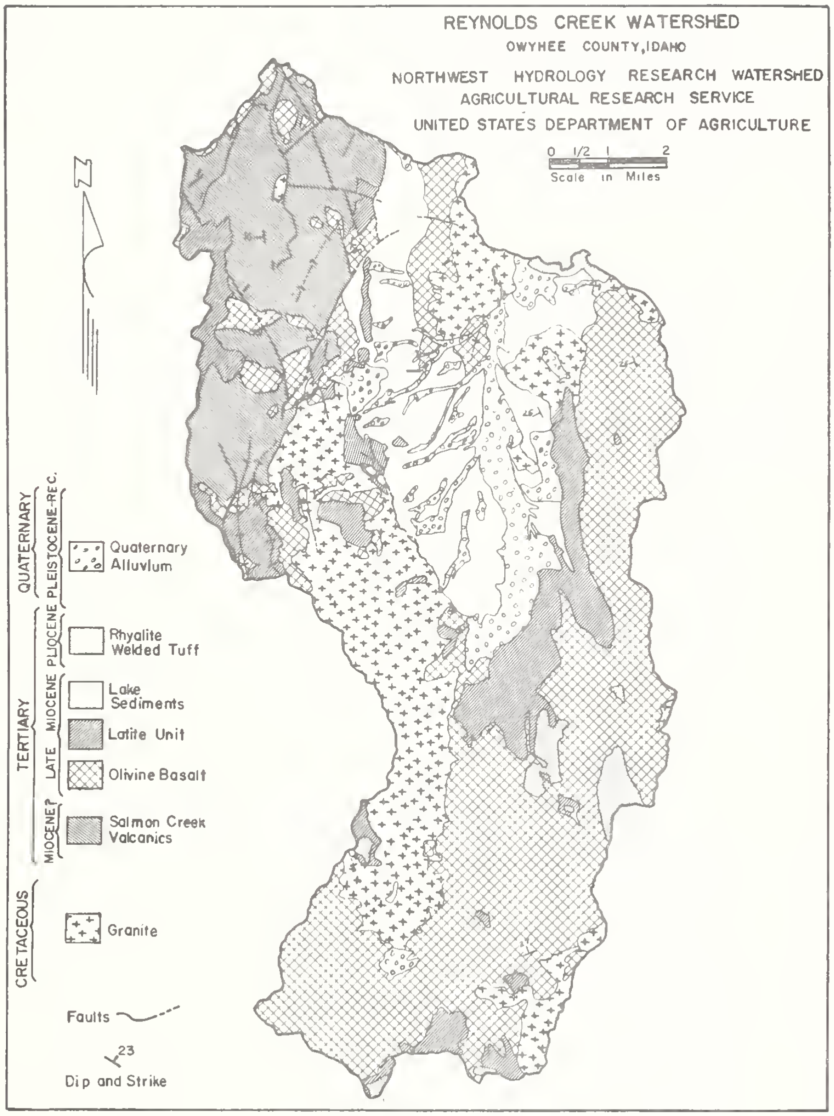


Figure 15. Generalized Geologic Map

RUNOFF AND SEDIMENT

The objectives of runoff and sediment research on the Reynolds Creek Experimental Watershed in cooperation with the Bureau of Land Management, USDI, are (1) to determine streamflow and sediment yield characteristics of representative sagebrush rangelands over a wide range of climatic and physical conditions, (2) to provide data for water balance and watershed modeling investigations, and (3) to determine the effects of range management programs and changes in land use. Also, studies of floods, erosion, and sediment transport are directed to solving problems in engineering design and reduction in damage to channels and structures. Table 6 and Figure 16 indicate runoff measurement sites.

Weirs and flumes for streamflow measurement on Reynolds Creek Watersheds were modeled in the hydraulic laboratory at Washington State University from 1960-1966. A unique drop-box weir design resulted from these laboratory studies and the weirs continue to function properly in measurement of heavily sediment-laden streamflow (Johnson, C. W., et al, 1966), Figures 17a and 17b.

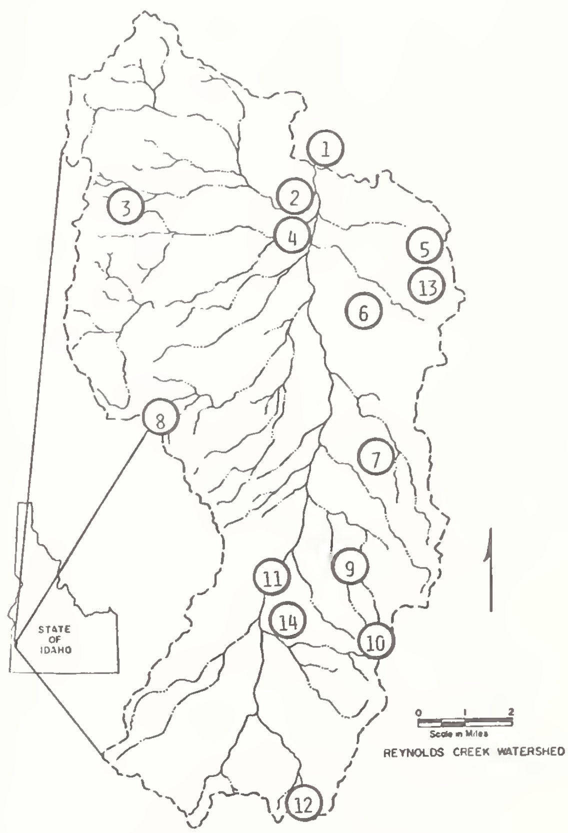


Figure 16. Locations of runoff and sediment instrumentation, Reynolds Creek Experimental Watershed, 1974.

TABLE 6.--Plots and watersheds instrumented for runoff and sediment measurement, Reynolds Creek Watershed, December 1974.

Watershed or Plot NAME	No.1/	Drainage Area (Acres)	Runoff Measuring Device	Suspended Sediment Sampler	Bedload Sediment Sampler
Reynolds Creek Outlet	1	57700	SCOV Weir	P.S. 67 Pump	Helley-Smith
Salmon Creek	2	8990	Drop-Box Weir	Hand Held	Helley-Smith
Murphy Creek	3	306	Drop-Box Weir	Hand Held	Detention Pond
Macks Creek	4	7846	Drop-Box Weir	P.S. 67 Pump	Helley-Smith
Summit	5	205	Drop-Box Weir	Gravity Flow	Detention Pond
Flats	6	2.24	V-Notch Weir	Single Stage	Detention Tank
Nancy Gulch	7	3.1	V-Notch Weir	Single Stage	Detention Tank
Whiskey Hill	8	119	V-Notch Weir	Hand Held	Detention Pond
Lower Sheep	9	33	Drop-Box Weir	Hand Held	Detention Box
Upper Sheep	10	63.4	Drop-Box Weir	Chickasha Pump	Detention Box
Reynolds Tollgate	11	13453	Drop-Box Weir	P.S. 67 Pump	Helley-Smith
Reynolds Mountain	12	100	V-Notch Weir	Chickasha Pump	Detention Box
PLOTS		ALL PLOTS: 14 feet wide, 72.6 feet long V-Notch Weirs, single stage samplers, overflow sample tank, and settling tank			
Summit	5				
Windy Point	13				
Nancy Gulch	7				
Upper Sheep	10				
Nettleton	14				
Reynolds Mountain	12				

1/ Numbers designate locations of weirs and plots in Figure 16

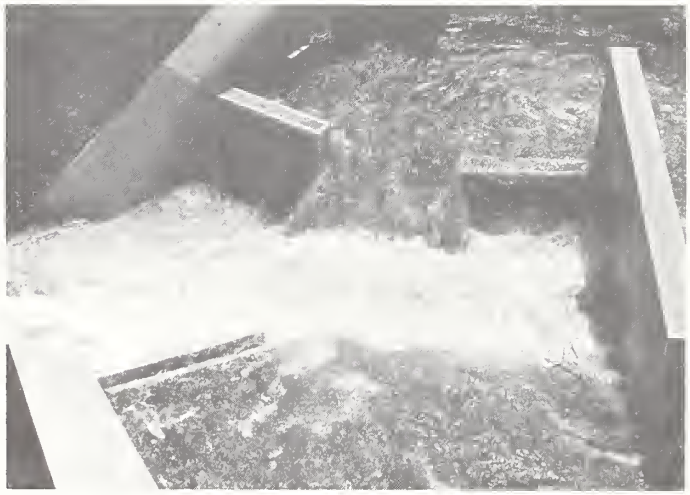


Figure 17a. Flow through the Drop-Box, showing flow turbulence.

Figure 17b. Tollgate Drop-Box Weir, Capacity 7,000 ft^3/sec and Drainage Area 21 mi^2.

Runoff

Yearly water yields from nine watersheds are listed in Table 7, and some stations show nearly a tenfold increase from the drought year of 1968 to wet years of 1965 and 1972. Monthly distributions of runoff at Reynolds Outlet, Reynolds Tollgate, and Reynolds Mountain are shown in Figure 18. Peak yearly rates are listed in Table 8. Most peak rates occur, as one notes, from winter storms of rain on melting snow and frozen soil. A study of these was made by Johnson and McArthur (1973).

TABLE 7.--Yearly water yield from Reynolds Creek Watersheds, 1963-1974 water years.

Water Year	Water Yield in Inches								
	Reynolds Outlet	Salmon Creek	Murphy Creek	Macks Creek	Summit	Lower Sheep	Upper Sheep	Reynolds Tollgate	Reynolds Mountain
1963	1.85	--	--	--	--	--	--	--	11.11
1964	2.45	--	--	--	--	--	--	--	21.03
1965	7.05	6.19	--	--	--	--	--	--	34.87
1966	.76	1.21	--	.64	--	.02	--	4.01	9.86
1967	2.18	2.66	--	1.70	0	.27	--	9.54	21.01
1968	.62	.88	1.39	.54	.08	.02	--	3.54	6.72
1969	3.60	3.60	8.41	3.28	.08	.45	--	11.84	22.43
1970	2.70	3.49	6.38	2.13	0	.02	1.21	10.13	20.06
1971	4.78	4.07	10.89	4.18	0	.26	4.71	15.42	31.07
1972	6.07	5.62	14.16	4.87	0	.91	5.16	16.57	33.51
1973	1.85	2.14	5.04	1.76	.01	.01	.77	6.00	13.24
1974	4.37	3.31	9.57	3.73	0	.26	3.31	12.75	26.65
	(1)1/	(2)	(3)	(4)	(5)	(9)	(10)	(11)	(12)

1/ Location on Figure 16

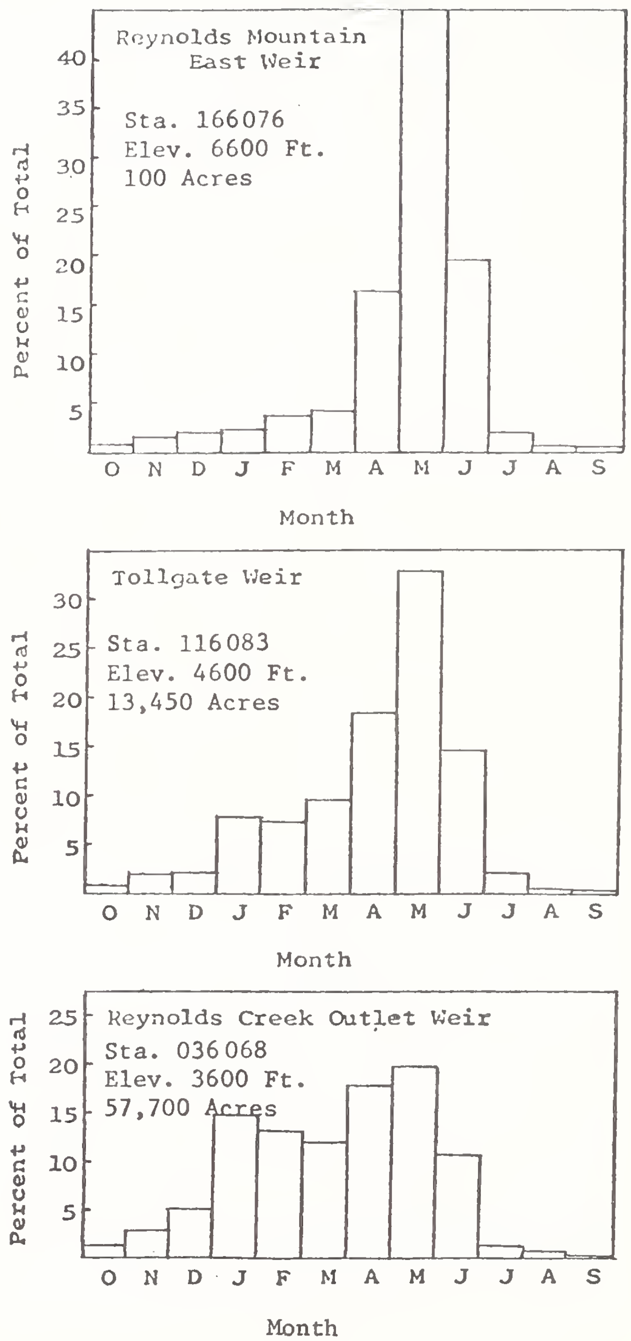


Figure 18. Distribution of Monthly Runoff at Selected Stations, Reynolds Creek Watershed

TABLE 8.--Yearly peak streamflow rates and dates of occurrence, selected Reynolds Creek Watershed Stations, 1963-1974.

	Reynolds Creek (1)[1/] Outlet Weir		Reynolds Creek (11) Tollgate Weir		Reynolds Mountain East Weir (12)	
Water Year	Date	Peak Flow (cfs)	Date	Peak Flow (cfs)	Date	Peak Flow (cfs)
1963	Jan. 31	2331	--	--	Apr. 29	4.16
1964	Jan. 25	188	--	--	May 16	3.60
1965	Dec. 23	3850	--	--	Dec. 23	10.70
1966	Apr. 1	59	Apr. 1	59	May 5	1.43
1967	June 7	265	June 7	288	May 22	5.44
1968	Feb. 21	327	Feb. 21	186	Aug. 10	1.48
1969	Jan. 21	900	Jan. 21	405	May 12	3.88
1970	Jan. 27	729	Jan. 27	240	May 17	5.89
1971	Jan. 18	540	May 6	193	May 4	5.77
1972	Mar. 2	678	Mar. 2	271	June 6	6.26
1973	Apr. 17	166	Apr. 17	147	May 8	3.31
1974	Mar. 29	291	Mar. 29	195	May 7	4.33
Average		859		220		4.69

1/ (1) Location sites, Figure 16.
(11) Location sites, Figure 16.
(12) Location sites, Figure 16.

Sediment

Sediment measuring and sampling facilities at streamflow stations are listed and described in Table 6. Sediment yield data from six source areas are summarized in Table 9. Similar data from four watersheds are summarized in Table 10. Years of high runoff and greatest peak streamflow usually produce the greatest sediment. Yearly streamflow, maximum sediment concentrations, and sediment yield at four watershed stations are listed in Table 11. Frequently a single storm event produces a major portion of the yearly sediment yield.

TABLE 9.--Source area data summary, water year basis, Reynolds Creek Watershed

Information	Source Area					
	Summit	Flats	Nancy Gulch	Whiskey Hill[1/]	Upper Sheep	Reynolds Mountain
Location No.	1	2	3	4	5	6
Drainage area (ha)	83.02	.91	1.26	48.20	25.68	40.40
Ave. elevation (m)	1364	1188	1428	1684	1945	2082
Ave. precipitation (mm)	254	254	305	508	460	1040
Weir type	drop-box	V-notch	V-notch	V-notch	drop-box	drop-box
Type suspended sed. sampler	gravity	single stage	single stage	none	pumping	pumping
Years of record	7	3	3	10	5	8
Ave. runoff (mm/yr)	0.6	4.0	5.7	42.2	77.0	532.5
Peak streamflow date	6-19-69	1-18-72	1-18-72	--	3-2-72	6-6-72
mm/hr	6.23	1.85	1.71	--	0.30	1.58
m^3/sec	1.42	.004	.006	--	.02	.18
ft^3/sec	50.70	.16	.21	--	.77	6.25
Max. conc. (ppm)	--	1413	900	--	5000	1380
Ave. sed. yield						
(tonnes/ha/yr)	.76	.02	.04	.29	.31	.43
(tons/A/yr)	.34	.01	.02	.13	.14	.19

1/ Yearly sediment accumulations were measured in a lined pond. The sediment deposition efficiency of the pond was estimated at 90 percent.

TABLE 10.--Watershed descriptions and data summary for Reynolds Creek and subwatersheds, water year basis

Information	Watershed			
	Reynolds at Outlet	Salmon Creek	Macks Creek	Reynolds at Tollgate
Location No.	7	8	9	10
Drainage area (ha)	23369	3641	3177	5448
Ave. elevation (m)	1495	1485	1504	1861
Ave. slope (percent)	17.4	21.6	17.9	19.1
Ave. precipitation (mm)	500	480	485	777
Weir type	SCOV 1/	drop-box	drop-box	drop-box
Runoff record (yrs)	12	10	9	9
Runoff record began	1963	1965	1966	1966
Sediment record (yrs)	8	7	7	8
Ave. runoff (mm/yr)	81.0	84.2	64.4	253.4
Ave. sediment yield				
(tonnes/ha/yr)	1.14	1.90	1.57	1.50
(tons/A/yr)	.51	.85	.70	.67

1/ SCOV is abbreviation for Self-Cleaning Overflow V-notch Weir (Bloomsburg and Tinney, 1961).

TABLE 11.--Yearly peak flow rates, date of occurrence, runoff, maximum suspended concentration, and sediment yield, Reynolds Creek and subwatersheds, by water year

Watershed	Year							
	1967	1968	1969	1970	1971	1972	1973	1974
Reynolds Outlet								
Peak flow (m^3/sec)	7.39	9.16	25.20	20.41	15.12	18.98	4.65	8.15
Date	6/7	2/21	1/21	1/27	1/18	3/2	4/17	3/29
Runoff (mm)	55.4	15.7	91.5	68.6	121.4	154.2	46.9	111.0
Max. conc. (ppm)	24700	16950	29170	15000	23000	14940	9990	6400
Sed. yield(tonnes)*	19630	6300	57183	22343	41638	54365	3510	8377
Salmon Creek								
Peak flow (m^3/sec)	2.38	.95	5.85	5.88	3.70	5.63	1.54	1.48
Date	1/21	2/21	1/21	1/27	1/18	1/18	4/14	3/17
Runoff (mm)	67.6	22.3	91.5	88.6	103.4	142.6	54.5	84.1
Max. conc. (ppm)	--	20000	32850	16350	24000	38250	18400	5550
Sed. yield(tonnes)*	--	551	12413	7349	7267	17905	2122	963
Macks Creek								
Peak flow (m^3/sec)	2.52	1.23	9.07	6.89	7.64	2.30	1.40	1.99
Date	1/21	2/21	1/20	1/27	1/18	6/9	4/14	3/14
Runoff (mm)	43.3	13.7	83.4	54.1	106.2	123.6	44.8	94.6
Max. conc. (ppm)	--	17850	20280	20300	19950	30000	16000	6930
Sed. yield(tonnes)*	--	570	9205	5311	8480	7870	1838	1764
Reynolds Tollgate								
Peak flow (m^3/sec)	8.06	5.21	11.34	6.72	5.40	7.59	4.12	5.46
Date	6/7	2/21	1/21	1/27	5/6	3/2	4/17	3/29
Runoff (mm)	242.4	89.9	300.8	257.3	391.6	420.9	152.5	323.9
Max. conc. (ppm)	58810	8640	20000	5540	7010	8580	4710	5200
Sed. yield(tonnes)*	13114	2286	15112	8422	11364	10280	1556	3242

* To convert metric tonnes to tons (2000 lb) multiply by 1.10.

Thunderstorm events have produced sediment in excess of five tons per acre during a single storm, see Figure 19. However, these storms usually affect only a few square miles and occur infrequently, which result in long-term sediment yield less than one ton per acre.

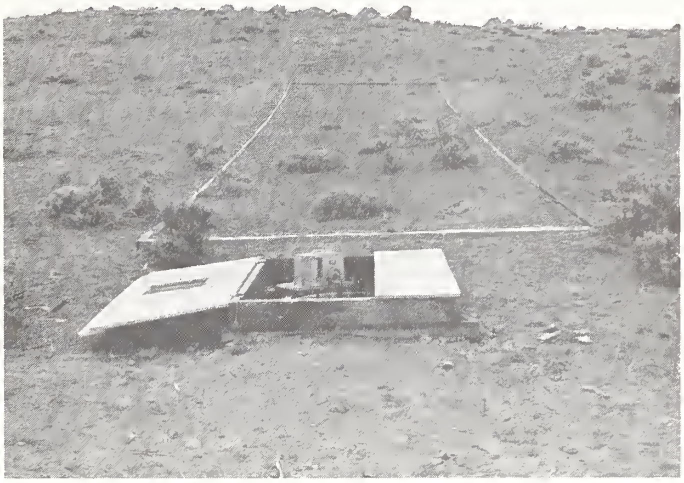


Figure 19. Micro-watershed instrumented for runoff and sediment measurements.

Sediment transport studies show that average bedload is about 20 percent of the total. Data were obtained using Helley-Smith bedload samplers, see Figure 20a and 20b, and depth-integrating hand samplers for suspended sediment. Sediment studies have been reported by Johnson, et al, (1974).

Figure 20a. Reynolds Creek Outlet bedload sampling with the 3-inch Helley-Smith Sampler

Figure 20b. Bedload sampling with 6-inch Helley-Smith Sampler

WATER QUALITY

In recent years, because of the increased concern for the quality of our environment, many agricultural practices have come under close scrutiny as potential sources of water pollution. Heavy grazing on open range may compact the soil, reduce infiltration, and seriously reduce the vegetative cover, thus increasing runoff with increased turbidity and contribution of sediment and nutrients to the streams. Irrigation return flow can contribute heavily to total salt and nitrate-nitrogen content downstream.

Information is needed on the water quality characteristics of rangeland watersheds under natural conditions and various land management practices. The Reynolds Creek Experimental Watershed offers an excellent opportunity to study water quality characteristics related to several of the abovementioned problems. No commercial fertilizers and limited application of pesticides have occurred on the watershed. Herbicides were used infrequently for sagebrush control, but not since 1965.

With the present distribution of hydrologic networks throughout the watershed, sampling of both surface and subsurface flow for water quality analyses can easily be accomplished and the water quality constituents can be related to the hydrology of the system, particularly the properties of the water, the distribution, and movement through and from the watershed.

This work is in cooperation with the Bureau of Land Management because of the expressed need for information on water quality changes influenced by rangeland management practices. As more rangeland is being used for recreation, this information becomes even more important. Boise State University is cooperating in the data collection and analysis program.

Water quality objectives are related to (1) concentrations of cattle on local areas of rangeland and quasi-feedlot conditions, (2) irrigation return flow, and (3) natural soil and geologic conditions.

Water quality samples have been collected and analyzed for chemical, physical, and bacteriological characteristics since October 1972. An average of 300 samples are collected per year at 14 sites. During the grazing season sample sites are increased to 21. Figure 21 shows sampling sites. Sample analyses are done at the ARS laboratory at Gowen Field or in cooperation with the Bureau of Reclamation at their Water Quality Laboratory in Boise.

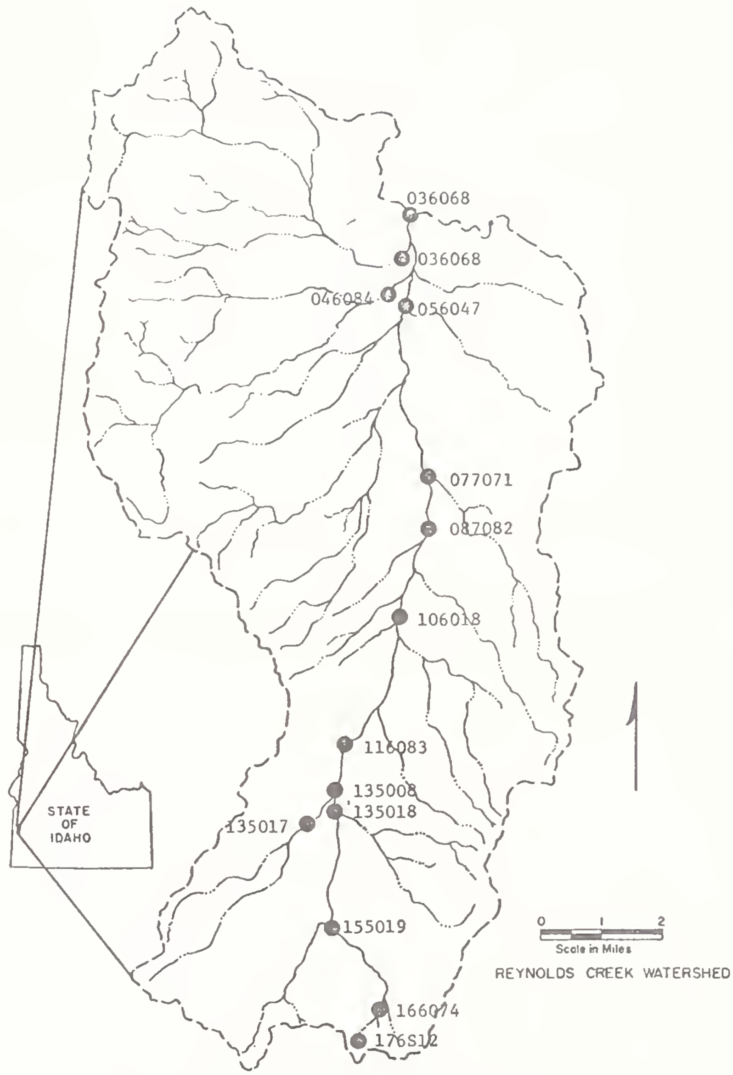


Figure 21. Index Map of Water Quality Sampling Sites, Reynolds Creek Watershed

Water Chemistry

A comparison of selected chemical parameters for two sites, one characterizing streamflow from open range and one from irrigation return flow, are given below in Figure 22.

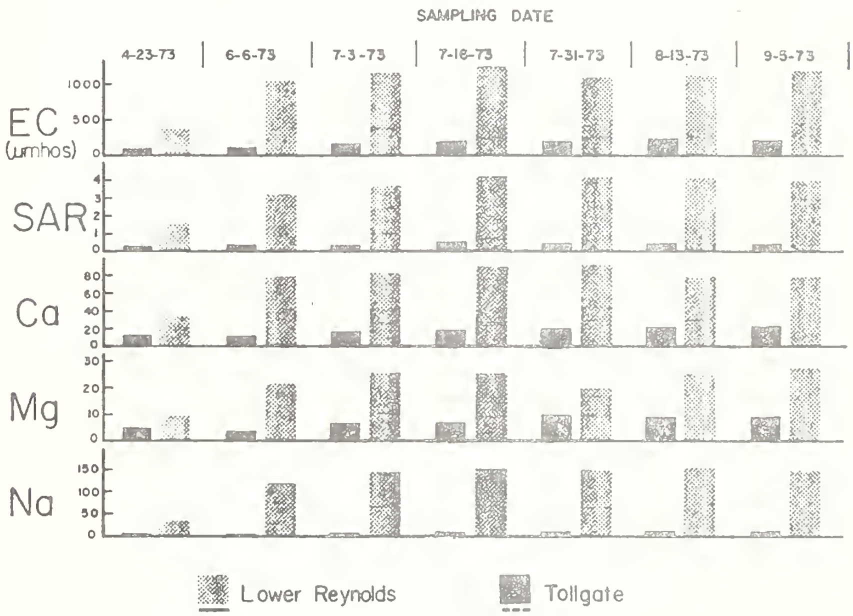


Figure 22. Selected Chemical Parameters for Two Sites

Marked changes occur in levels of concentrations at the Lower Reynolds site during the irrigation season, while levels of concentration at the Tollgate Site (no irrigation return flow) remain relatively constant.

The sodium adsorption ratio remains low, indicating that sodium is not a dominating alkali hazard in the irrigation return flow waters. The conductivity values increased considerably during the irrigation season, indicating a salinity increase in the lower reaches of Reynolds Creek. Sulphate, though not a hazardous constituent, is prominent during irrigation return flow. The major source of sulphates is isolated in one area of the watershed (Macks Creek Drainage Basin) where it is flushed from soils developed from lake sediment evaporites containing gypsum.

Phosphates seem to be related only to increases in streamflow and suspended sediments and are derived from the lake sediments. The higher nitrate readings found at the Reynolds Mountain spring and Reynolds Outlet Weir are derived from soluble organic materials. No commercial fertilizers are used on the watershed.

The chemical quality of Reynolds Creek water shows increases in chemical concentrations during the irrigation season, but is diluted rapidly at the end of the irrigation season by increased precipitation and runoff, and decreased irrigation return flow. There remains no evidence to show that any appreciable deterioration in the chemical quality of Reynolds Creek water results from grazing of livestock on open range.

Bacteriological Quality

The bacteriological quality of Reynolds Creek was studied to determine the affect of the presence of livestock. Cattle are generally taken from the fields and moved to open range in mid April to early June. The lower Reynolds sampling site, adjacent to winter feeding areas, shows higher levels of fecal and coliform counts than during the summer following removal of cattle to open range. Maximum counts reach 1,200 total and 800 fecal. Conversely, at the Reynolds Mountain Site on open range, counts reach an excess of 2,000 total and 1,000 fecal during the grazing season. Both sites have counts for total less than 100 and for fecal to zero when cattle are not present. This trend is constant for all sites on open range and on fields where winter feeding occurs.

The results of this study show the direct relationship between the activity of cattle and the bacteriological quality of Reynolds Creek.

Figure 23 shows a typical sample site, and Figure 24, laboratory procedures.

Figure 23. Sampling Site

Figure 24. Water quality analysis

EVAPOTRANSPIRATION AND SOIL WATER

This aspect of the research program is conducting evapotranspiration studies designed for measuring and predicting evapotranspiration under sparse vegetative cover and generally unsaturated soils.

Research objectives are:

1. To determine the evaporative loss of water from sagebrush rangelands, irrigated alfalfa, and stockponds, while observing pertinent meteorological parameters and the soil water status.

2. To develop, for predictive purposes, relationships for associating the evaporative loss with meteorological parameters, type and degree of surface cover, soil water, and potential evaporative demand.

3. To formulate and test predictive equations in general hydrologic simulation studies.

An extensive soil water sampling network is operated to provide soil water data to water balance and water use studies.

Figure 25 shows a lysimeter site, a weather station, and soil moisture measurement site.

Figure 25. Lysimeter, Weather, and Soil Water Investigations Site

Two pairs of hydraulic lysimeters were installed in 1967. These lysimeters are located in rangeland sites at the Reynolds Mountain and Lower Sheep meteorological stations. These lysimeters are 5 feet in diameter and 4 feet deep (Figure 26). Soil in the lysimeters is undisturbed and the monoliths were taken at each lysimeter site to preserve the natural vegetation. Soil water is measured biweekly in neutron access tubes that extend to the bottom of the lysimeters, and drainage candles are used to remove excess water. The two sets of rangeland lysimeters are equipped with recorders. Lysimeter data will be taken throughout the growing season to aid in the calibration and evaluation of evapotranspiration models.

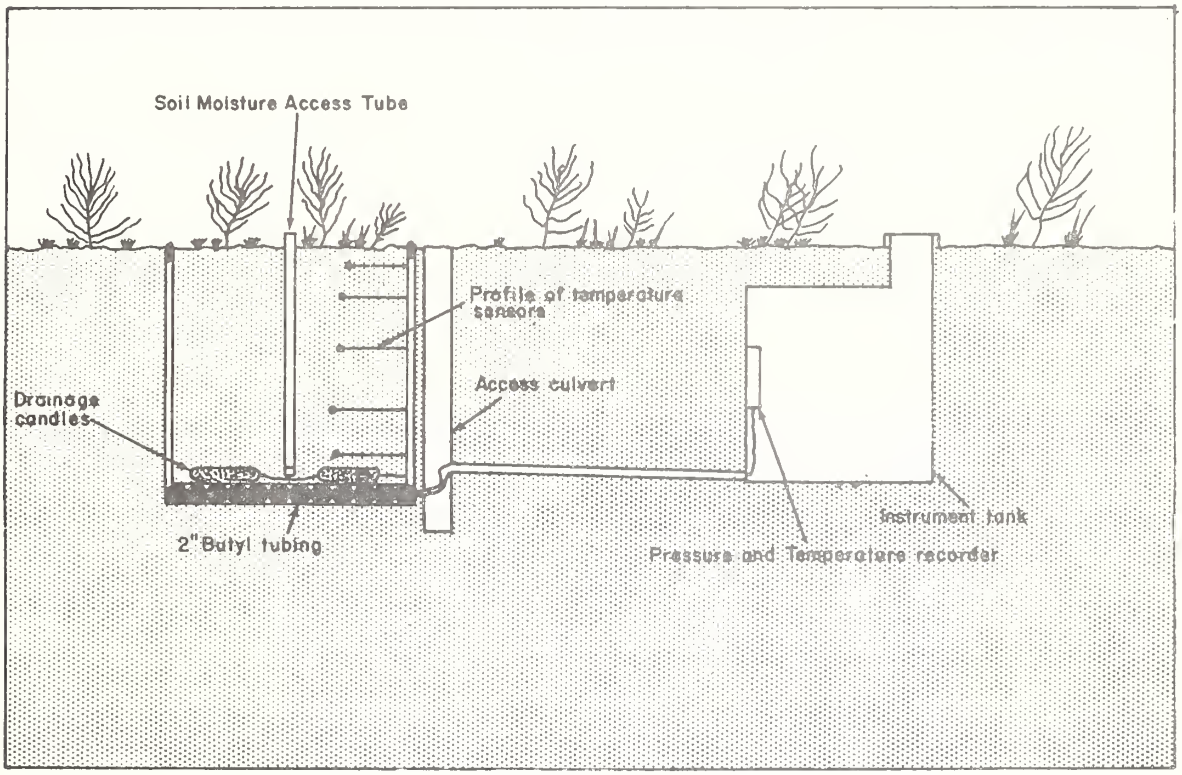


Figure 26. Diagram of Lysimeter Component Parts

The lysimeter data complement the biweekly soil water data obtained from a network of neutron access tubes located throughout the watershed. The access tube network was established in 1966 and 1967. These data will be used to develop the watershed water-use regimen and thus enable calibration of hydrologic models. In Figure 27 one site of the soil water network is being measured.

A study, using the soil water data from Summit, Lower Sheep, and Reynolds Mountain, was made to determine the soil water trends for the 1966-72 period at these locations. At the Summit, the average maximum soil water storage in the top 3 feet was 8.1 inches the last part of February and the minimum storage was 5.4 inches the last of July. The average evapotranspiration rate was 0.04 inch per day during the depletion period. At Lower Sheep the maximum storage was 11.2 inches in April and the minimum storage was 7.9 inches by late July. There was an average evapotranspiration rate of 0.07 inch per day during the depletion period. There was a maximum storage of 18.7 inches at Reynolds Mountain early in June and a minimum storage of 14.8 inches by the end of August. The average evapotranspiration rate was 0.10 inch per day during the depletion period. Minimum soil water storage at the three sites usually occurred from late July or August to October.

The model currently being tested for predicting rangeland ET was developed by Hanson (1975).

Figure 27. Soil Moisture

GROUND-WATER STUDIES

Aquifer Characteristics

Aquifer investigation of ground-water flow has been completed to determine aquifer characteristics of the major systems in the watershed. Relative transmissibility values of the major systems are given below.

TABLE 11.--Relative Transmissibilities of Lithologic Units

Lithologic Units	Relative Transmissibility Values (gpd/ft)
	0 500 8000
Lake Sediments	X-------------X
Silicic Volcanics	X-----X
Basalt	X-------------X
Granite	X-----X
Alluvium	X-----X

The silicic volcanics, granite, and alluvium make up such a small part of the overall ground-water flow system that their contribution to ground-water flow in the watershed is insignificant. The basalt and lake sediment formations contain the major aquifer systems. Recharge into these two systems occurs following major periods of rainfall or during snowmelt. Recharge occurs mostly through rock outcrops and very shallow soils.

Mathematical Simulation of Subsurface Flow

A mathematical model of subsurface flow was used to complement a field study of snowmelt runoff in a small upstream source area in the watershed. Field measurements from an instrumented cross-section of this small watershed show that the mechanism of streamflow generation is subsurface delivery of meltwater over limited distances through shallow high-permeability, low-porosity formations of altered and fractured basalt. The mathematical model provides a two-dimensional transient saturated-unsaturated analysis of the subsurface flow at the field site. It provided a valuable aid to a unified interpretation of the field measurements.

Stock Water Development from Shallow Aquifer Systems

Aquifer investigations in the northeast portion of the watershed have determined that static water levels do not exceed 45 feet, and that drawdown was as much as 48 feet when the wells were pumped 3 to 6 gallons per minute for 72 hours. In cooperation with the Bureau of Land Management a 310-foot-deep well was equipped with a submersible pump to fill a 20,000-gallon storage tank. Water was piped from the storage tank through 2 miles of pipeline, and distributed to four stock tanks to allow grazing over several sections of rangeland.

Over a period of 5 years this well has been pumped at 5 gallons per minute, averaging 70 days each year for the spring and early summer grazing season. Approximately 126,000 gallons of water are pumped each season for 150 to 200 head of livestock. The well has developed to the extent that pumping rates can be increased when there is sufficient recharge to the aquifer system.

A local ground-water discharge spring was developed, which now produces an annual flow rate of 7 to 12 gallons per minute. This spring discharges from ground-water storage in an area where an impermeable zone intersects ground-water flow in the basalt aquifer system. It can supply water for between 600 and 1,000 head of cattle per day, but the range in this area can provide enough forage for only 200 to 300 cattle. Consequently, excess water from this spring can be distributed to adjacent range that has no water.

The success of these developments results from the favorable geologic and aquifer conditions. Stock water is now distributed to areas that previously were without an adequate supply. The range forage is now grazed as a part of a systematic grazing plan. Figure 28 is of a stock water site.

Figure 28. Spring Development Site for Stock Water

Chemical Analysis of Ground-Water Flow Systems

Water samples were collected and analyzed over a 5-year period from ground-water flow in a basalt and lake sediment multiple-aquifer system on the Reynolds Creek Watershed. Analyses of the major chemical constituents indicate the presence of at least two water types. The basalt waters are characteristically higher than the lake sediment waters in HCO_3^-, Ca^{++}, Mg^{++}, and SiO_2, while the lake sediment waters are higher in Cl^-, $SO_4^=$, and Na^+. Springs were classified according to discharge from basalt or lake sediment flow systems on the basis of these characteristic ion concentrations.

Total ionic concentrations were found to increase in a predictable manner, progressing downstream in the flow system. The TDS/SiO_2 ratio was the most useful tool for this determination.

A further analysis was made of the basalt aquifer flow system to determine how chemical constituents of a water sample vary with changes in water level elevation at a point during recharge. Theoretically, during recharge to a ground-water system, dilution should cause a decrease in ionic concentrations. Ionic concentrations should increase during recession. Examination of well hydrographs and chemical analyses of these waters did not show this effect. Rather, variations in water chemistry were random and not related to ground-water levels. The variations in the water chemistry at a site are probably due to the random occurrences of secondary mineralization, especially the sodium zeolites and hydrous silicates, and the wide variations in the fracture system of the basalt.

The results of this work have been beneficial in determining position in flow systems and in source of and expected value of ground-water discharge springs. A ground-water monitoring site is shown in Figure 28.

Figure 29. Ground-Water Monitoring Gage in Foreground and Stock Water Tank in Background

WATERSHED MODELING

The development of computer hardware and software over the past decade has provided the impetus for many significant advances in the development of models that simulate hydrologic components or watershed hydrologic performance. Two philosophies appear to classify modeling as either determination or stochastic. Debate on the pros and cons of the types of models is largely irrelevant. What is important is the problem to be tackled, the quality and quantity of input data and information available, and the purpose for which hydrologic predictions are required. At the Center, modeling activity focuses on combining and interrelating component models, such as snowmelt, infiltration, runoff, evapotranspiration, streamflow and erosion, and sediment yield into watershed models.

The watershed models provide input data for such needs as environmental impact evaluations, water quality predictions, sediment yield modeling, storm runoff models or rangeland forage productivity.

Research objectives are:

1. To make a comprehensive review of existing watershed models.

2. To test existing watershed models with data from Reynolds Creek Watershed data.

3. To improve watershed model components for a sagebrush rangeland watershed, which present models do not satisfactorily represent.

4. To utilize the models to forecast the influence of land use and treatment and/or management, such as grazing systems on watershed runoff quality and quantity.

5. To apply the watershed models to other sagebrush rangeland watersheds in the Northwest.

The current modeling research is directed toward adapting the "USDAHL-74 Revised Model of Watershed Hydrology" to the 205-acre Summit Basin, a subwatershed of the Reynolds Creek Experimental Watershed. This model is a modification of the "USDAHL-70 Model of Watershed Hydrology" and was chosen for testing because the various model components can be individually adapted to the varying watershed conditions. The Summit Basin subwatershed was chosen because the necessary soils information is available, and it is not a snowpack runoff area. The first computer runs have been completed.

The East Reynolds Watershed has been selected as the first watershed to model where principle runoff is from a melting snowpack. The necessary subroutines for this watershed are now being developed to also be used in the "USDAHL-74 Revised Model of Watershed Hydrology".

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